

What is claimed

- 1 1. A manipulator for positioning and orienting a test head, comprising:
2 an elongated blade¹⁰ that extends along a central axis from a region outside the test
3 head into an internal region of the test head; and
4 an interface coupling disposed in the internal region of the test head, having a first
5 portion coupled to the elongated blade and a second portion²²⁴ coupled to the test head, the
6 first and second portions being free to rotate with respect to each other in compliance
7 about at least one axis of rotation.
- 1 2. The manipulator of claim 1, wherein interface bearing includes a bearing
2 assembly²⁴⁶, the first portion of the interface coupling including a first race of the bearing
3 assembly and the second portion of the interface coupling including a second race of the
4 bearing assembly.
- 1 3. The manipulator of claim 2, wherein the bearing assembly is a spherical bearing²⁴⁶,
2 and the first and second races are free to rotate with respect to each other in compliance
3 about all axes of rotation.
- 1 4. The manipulator of claim 3, wherein the first race is an outer race of the spherical
2 bearing and the second race is an inner race of the spherical bearing.
- 1 5. The manipulator of claim 3, further comprising a transition insert²²⁴ disposed in the
2 internal region of the test head and having an opening into which the elongated blade
3 enters, wherein the transition insert is coupled to the test head and fixedly attached to the
4 first and second races of the spherical bearing.
- 1 6. The manipulator of claim 5, further comprising at least one linear coupling
2 oriented in parallel with the central axis and having first and second elongated
3 components, the first component being coupled to the test head^{110a, b} and the second
4 component being coupled to the transition insert²²⁴, the first and second components being
5 movably coupled to each other.
- 1 7. The manipulator of claim 6, further comprising a linear adjustment mechanism^{218, 220},
2 having a first portion coupled to the test head and a second portion coupled to the

3 transition insert, wherein the linear adjustment mechanism is adapted to move the test
4 head along the at least one linear coupling relative to the elongated blade.

1 8. The manipulator of claim 1, further comprising at least one linear coupling
2 oriented in parallel with the central axis and having first and second elongated
3 components, the first component being coupled to the test head and the second
4 component being coupled to the elongated blade, the first and second components being
5 movably coupled to each other.

1 9. The manipulator of claim 8, wherein the first component of each at least one
2 linear coupling includes one of a truck and a rail, and the second component of each at
3 least one linear coupling includes the other of the truck and the rail.

1 10. The manipulator of claim 9, wherein the at least one linear coupling includes two
2 linear couplings disposed on opposing sides of the elongated blade.

1 11. The manipulator of claim 9, wherein the at least one linear coupling comprises
2 one linear coupling, and further comprising an elongated guide, the one linear coupling
3 and the elongated guide being disposed on opposing sides of the elongated blade.

1 12. The manipulator of claim 8, wherein the interface coupling further includes a
2 linear adjustment mechanism, having a first portion coupled to the test head and a second
3 portion coupled to the elongated blade, the linear adjustment mechanism being adapted to
4 move the test head relative to the elongated blade along the at least one linear coupling.

1 13. The manipulator of claim 12, wherein the linear adjustment mechanism includes
2 at least one lead screw, the lead screw engaging a threaded region of the test head and
3 having a termination coupled to the elongated blade.

1 14. The manipulator of claim 12, wherein the linear adjustment mechanism includes
2 at least one lead screw, the lead screw engaging a threaded region of the elongated blade
3 and having a termination coupled to the test head.

1 15. The manipulator of claim 1, further comprising a transition insert disposed in the
2 internal region of the test head and having an opening into which the elongated blade

3 enters, the transition insert being coupled to the test head and fixedly attached to the first
4 and second portions of the interface coupling.

1 16. The manipulator of claim 15, wherein the interface coupling includes a spherical
2 bearing wherein the first portion of the interface coupling includes an outer race of the
3 spherical bearing and the second portion of the interface coupling includes an inner race
4 of the spherical bearing.

1 17. The manipulator of claim 16, wherein the elongated blade has a hole in which the
2 spherical bearing is disposed, and the transition insert further comprises:
3 left and right plates, disposed on opposing sides of the elongated blade, each
4 having a hole that aligns with the hole in the elongated blade; and
5 a shaft passing through the holes in the left and right plates, though the hole in the
6 elongated blade and engaging the inner race of the spherical bearing.

1 18. The manipulator of claim 17, wherein the transition insert further includes:
2 left and right retainers fixedly attached to the elongated blade on opposing sides of
3 the hole in the elongated blade and engaging the outer race of the spherical bearing.

1 19. A manipulator for positioning and orienting a test head, comprising:
2 a stiffener fixedly attached to the test head and having top, bottom, and back
3 portions;
4 an elongated blade extending along a central axis from a region outside the test
5 head into an internal region of the test head between the top and bottom portions of the
6 stiffener and in front of the back portion of the stiffener; and
7 an interface coupling having a first portion coupled to the elongated blade in the
8 internal region of the test head and a second portion coupled to the stiffener, the first and
9 second portions of the interface coupling being free to rotate with respect to each other in
10 compliance about at least one axis of rotation.

1 20. The manipulator of claim 19, further comprising a transition insert disposed in the
2 internal region of the test head and having an opening into which the elongated blade
3 enters, wherein the transition insert is coupled to the stiffener and fixedly attached to the
4 first and second portions of the interface coupling.

1 21. The manipulator of claim 20, further comprising at least one linear coupling
2 oriented in parallel with the central axis and having first and second elongated
3 components, the first component being coupled to the stiffener and the second component
4 being coupled to the transition insert, the first and second components being movably
5 coupled to each other.

1 22. The manipulator of claim 21, further comprising a linear adjustment mechanism,
2 having a first portion coupled to the stiffener and a second portion coupled to the
3 transition insert along the at least one linear coupling.

1 23. The manipulator of claim 22, wherein the interface coupling includes a spherical
2 bearing having an outer race coupled to the first portion of the interface coupling and an
3 inner race coupled to the second portion of the interface coupling.

1 24. The manipulator of claim 23, wherein the elongated blade has a hole within which
2 the spherical bearing is disposed, and the transition insert has left and right plates, each
3 having holes, disposed on opposing sides of the elongated blade, the transition insert
4 including:
5 a shaft passing through the holes in the left and right plates, and through the hole in
6 the elongated blade and engaging the inner race of the spherical bearing.

1 25. The manipulator of claim 24, wherein the retaining mechanism further includes:
2 left and right retaining plates disposed on opposing sides of the hole in the
3 elongated blade, each having a hole through which the shaft passes, and being fixedly
4 attached to the elongated blade and to the outer race of the spherical bearing.

1 ²⁶~~30~~. A method of assembling a test head for use with a manipulator, comprising:
2 providing a stiffener having top, bottom, and back portions, and left and right
3 mounting surfaces;
4 inserting an elongated blade into an internal region between the top and bottom
5 portions of the stiffener and in front of the back portion of the stiffener;
6 attaching the elongated blade to the stiffener; and
7 fastening respective first and second portions of the test head to the left and right
8 mounting surfaces of the stiffener.

WHERE ARE
CLAIMS
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31. The method of claim 30, wherein the step of attaching the elongated blade to the stiffener includes attaching an outer race of a spherical bearing to the elongated blade and attaching an inner race of the spherical bearing to the stiffener.

32. The method of claim 31, further comprising balancing the test head on the spherical bearing by adjusting a distance between the back portion of the stiffener and the elongated blade.

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